Finite Impulses Response Filters for Compton Edge reconstruction & Background G4 studies

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LUXE analysis TF meeting
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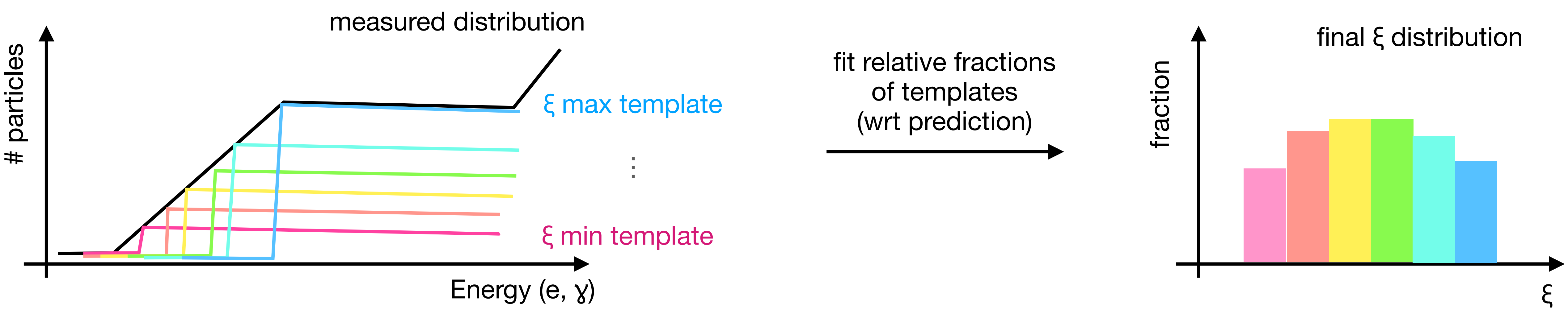
Reminder: Why we are interested in the kink

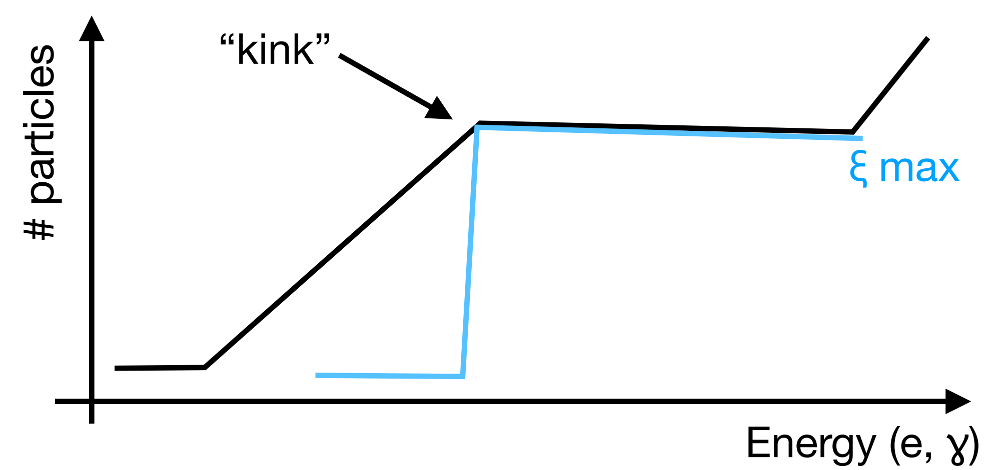
- Gaussian pulse: overlay of different true ξ leads to dramatic washing-out of edges
- final analysis should be a template fit (template of different ξ bins) fit to the spectrum



For the CDR propose simple approach:

- instead of differentiation, try to find the “kink” of the edge
- for low enough ξ (high w0) , this position corresponds to $ξ_{max}$

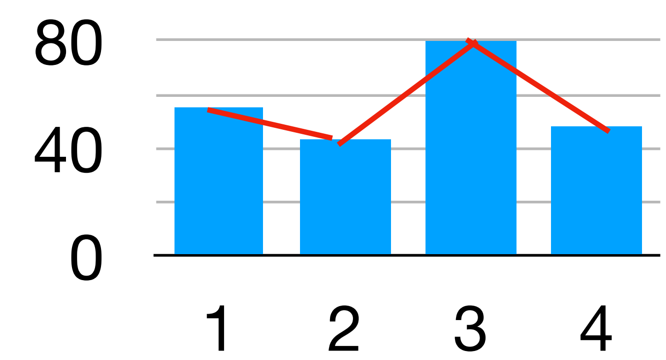
← **Today!**



Finite Impulses Response Filter (FIR)

Before: Simple Differentiation for Edge finding

- get electron x distribution
- calculate slope bin-by-bin
  → bin with max. slope = edge
- susceptible to statistical fluctuations!



method used by J. List et. al.

Finite Impulses Response Filter

- edge-like features in function **g(x)** can be identified by maxima in the convolution **R(x)=h(x)∗g(x)** where **h(x)** is a matched filter
- **R(x)** is called the **Response**
- we have discrete data points **x=**$(x_0,\ldots,x_i)$, need discretized Response $R_d(i)$

$$R_d(i) = \sum_{k=-N}^{N} h_d(k) \cdot g_d(i-k)$$

- different filters h_d available, optimal choice depends on the function g(x)
- Used here: **First derivative of a Gaussian (FDOG)**

$$h_d(k) = -k \exp(-\frac{k^2}{2\sigma^2}) \text{ for } -N \leq k \leq N$$

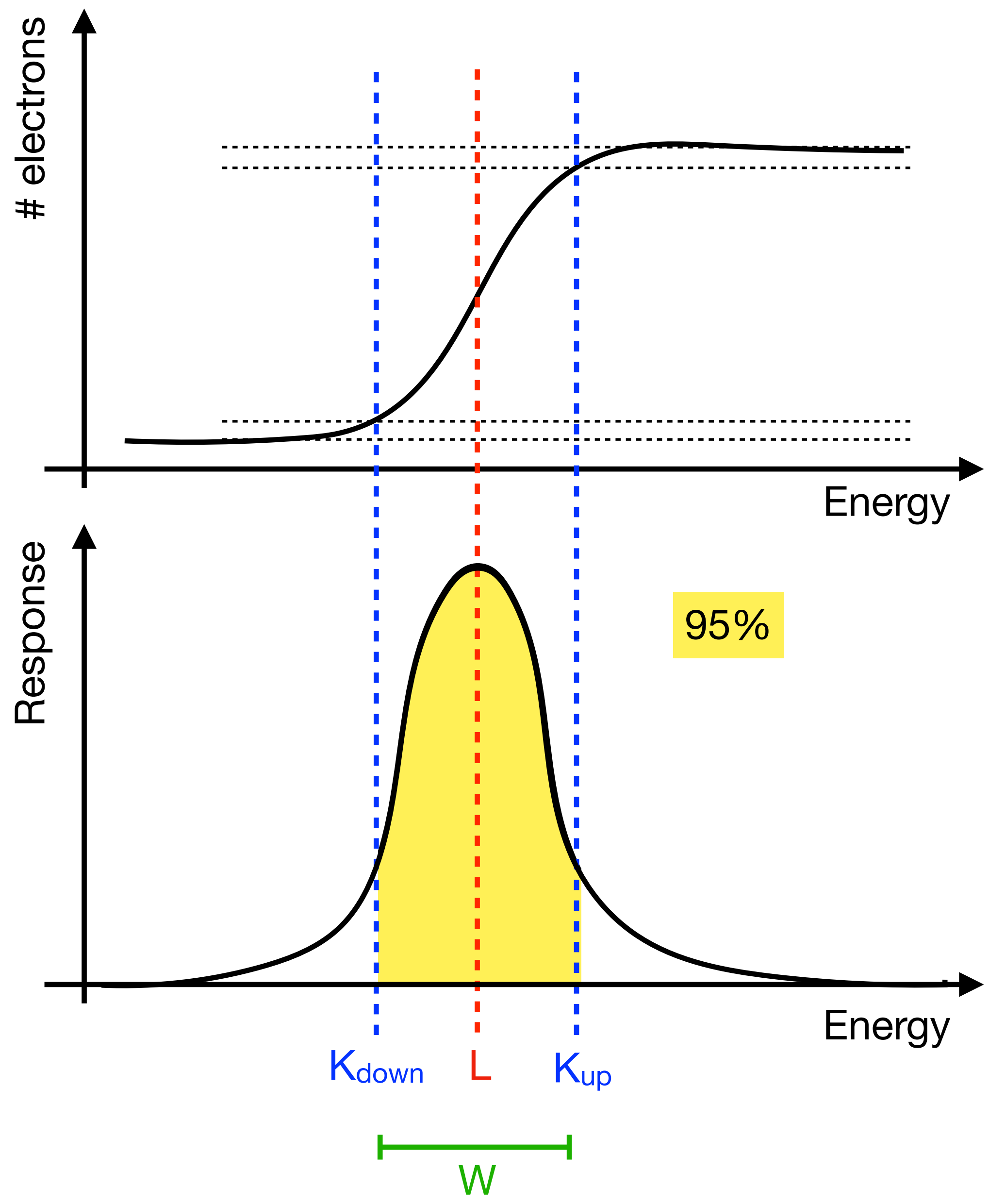
FIR approximates first derivative

— thanks to filters more robust against statistical fluctuations!

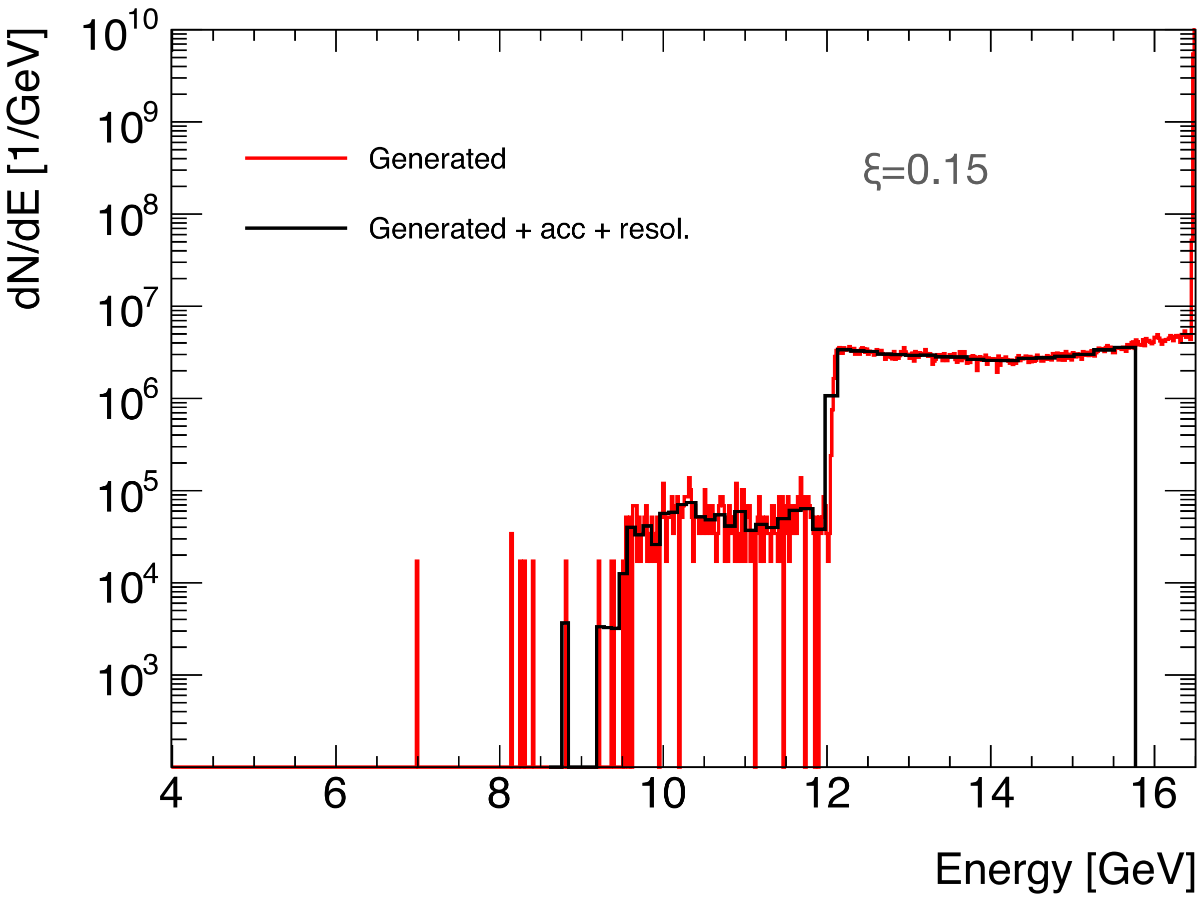
Finite Impulses Response Filter (FIR)

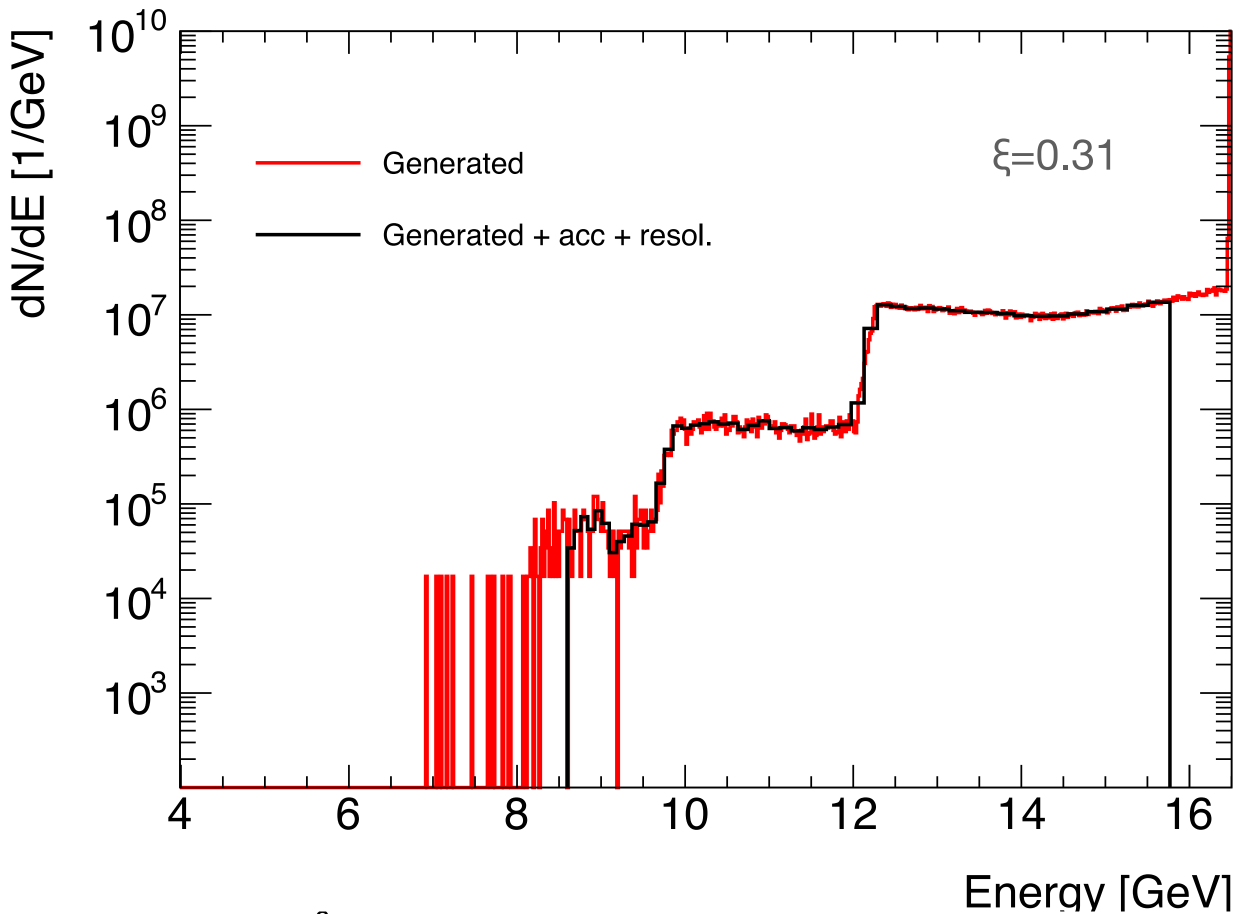
Features of interests:

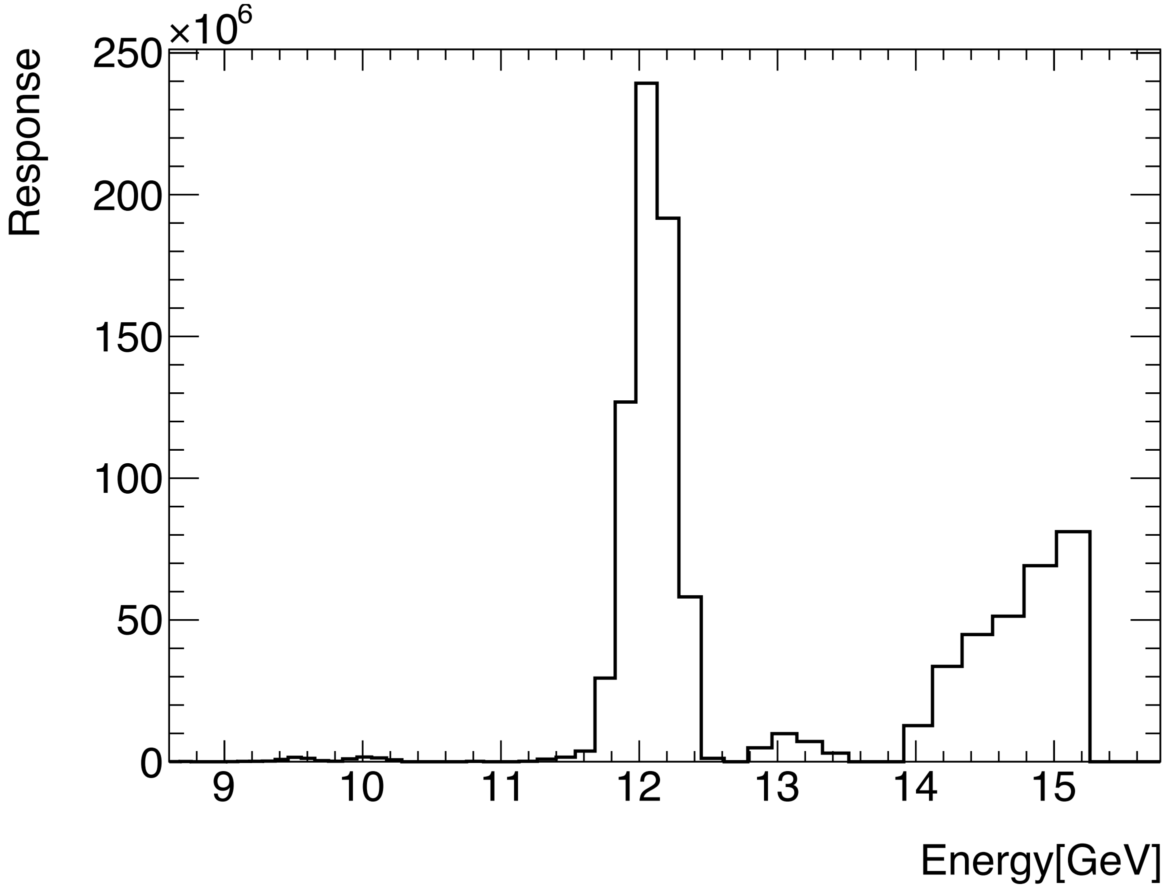
- location **L**: edge position, maximum of Response
- kinks $\mathbf{K_{up/down}}$: edge start/end points, determined by finding 95% interval of Response function
- alternative $\mathbf{K_{up/down}}$: zero-crossing of Response
- width $\mathbf{W = K_{up} - K_{down}}$
- Note: Response is not necessarily Gaussian!
  → K_{up} and K_{down} can be very asymmetric

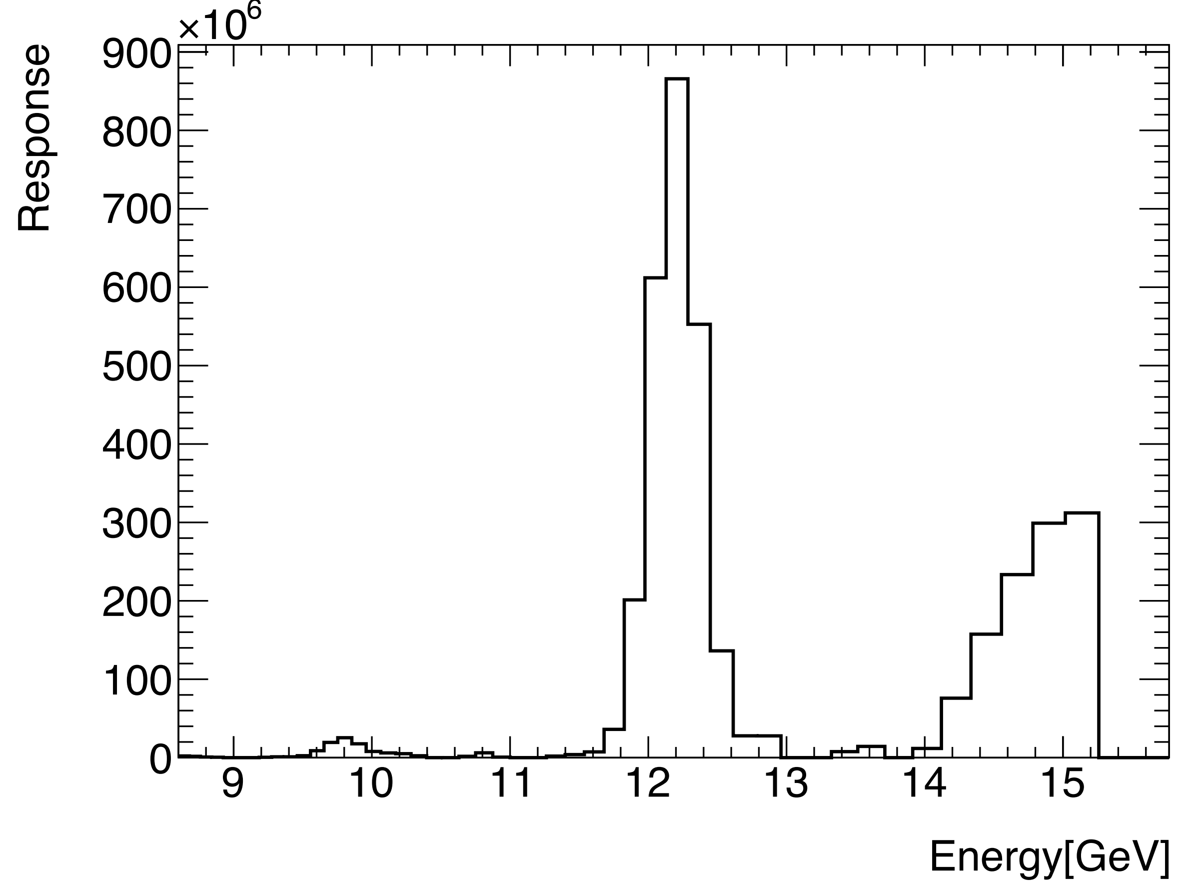


Spectra & Response

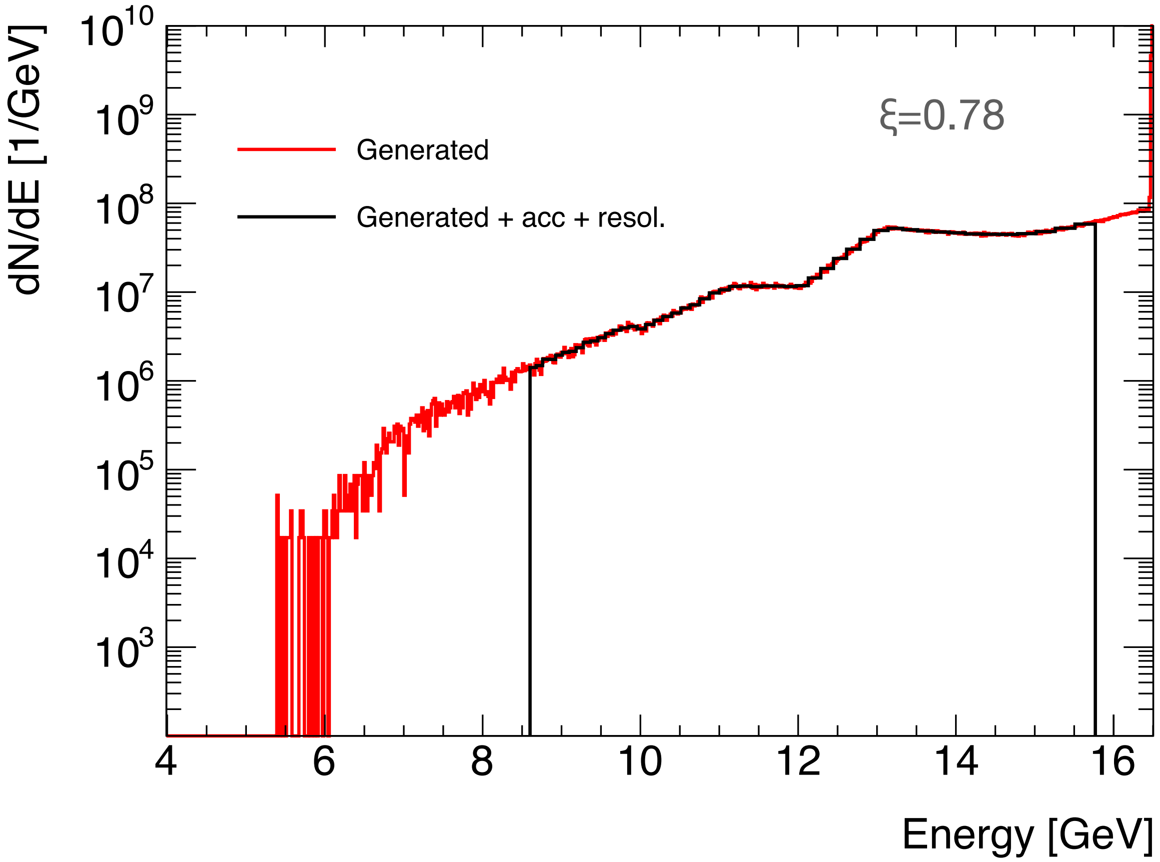


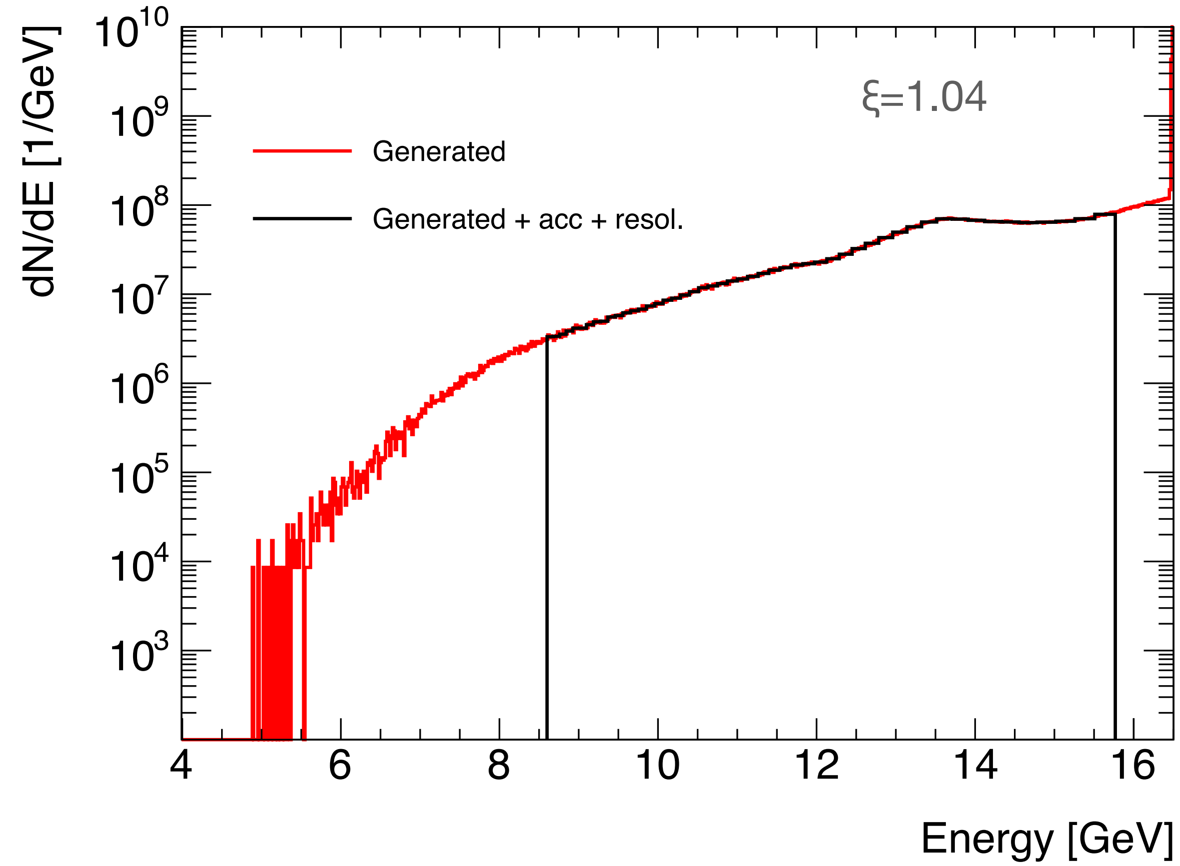


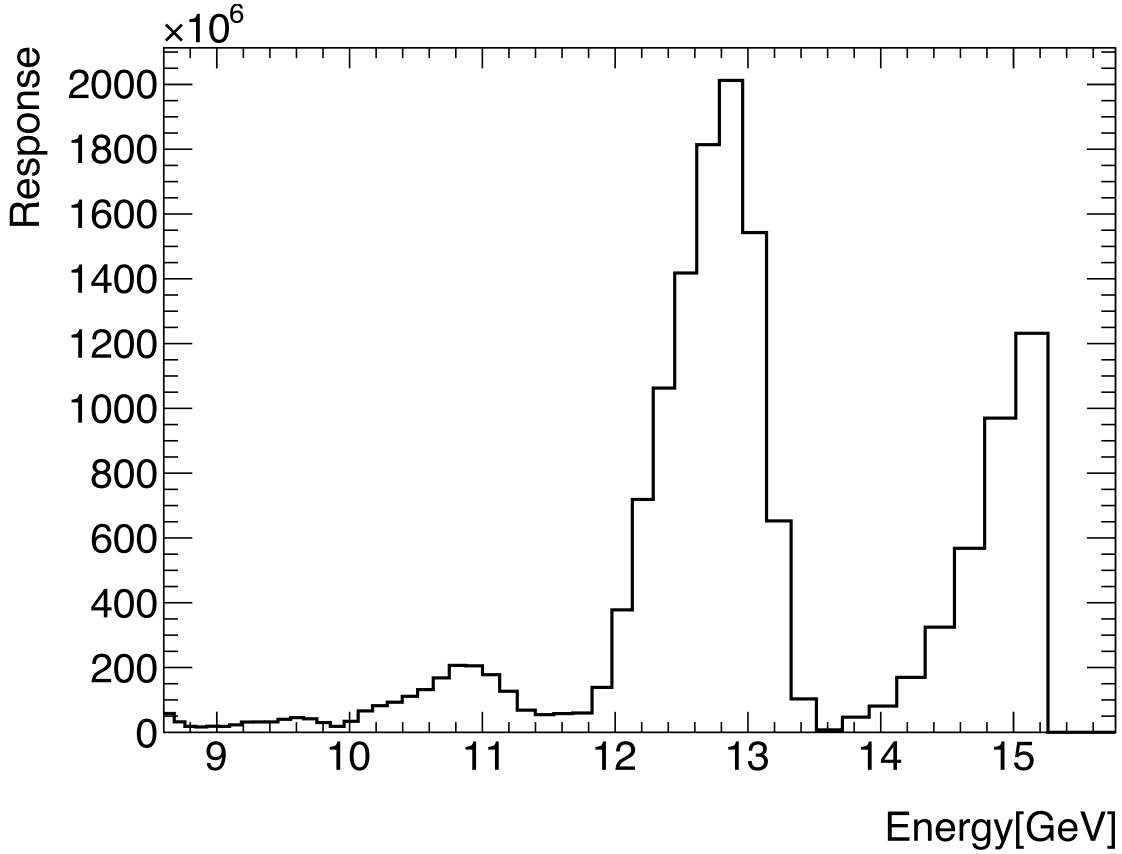


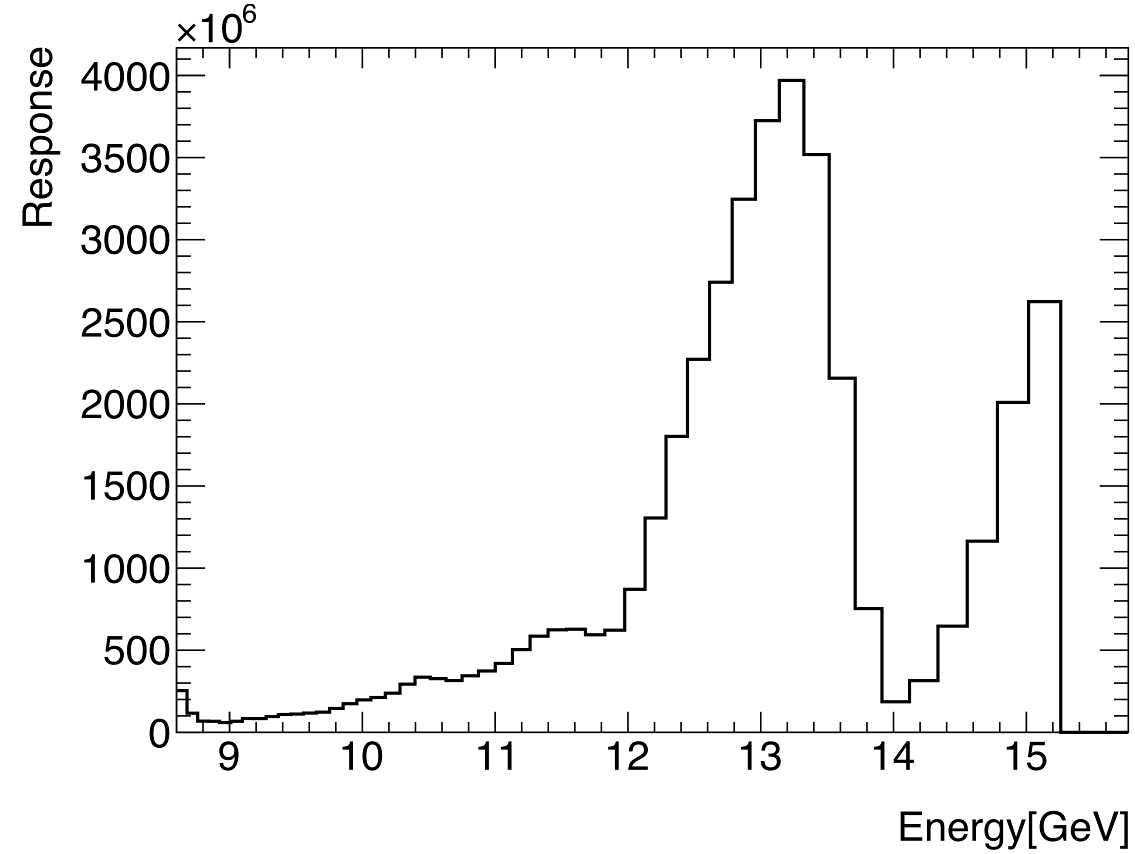


Spectra & Response

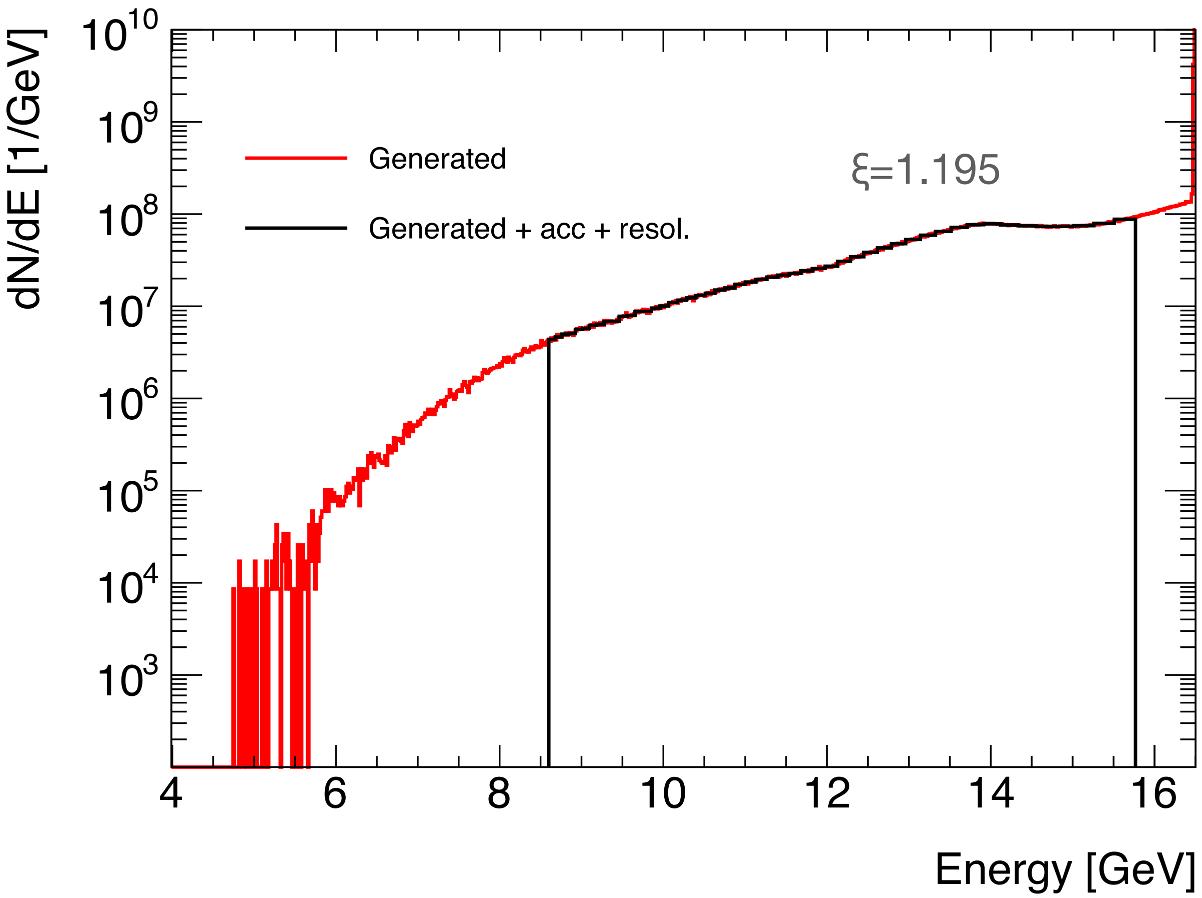


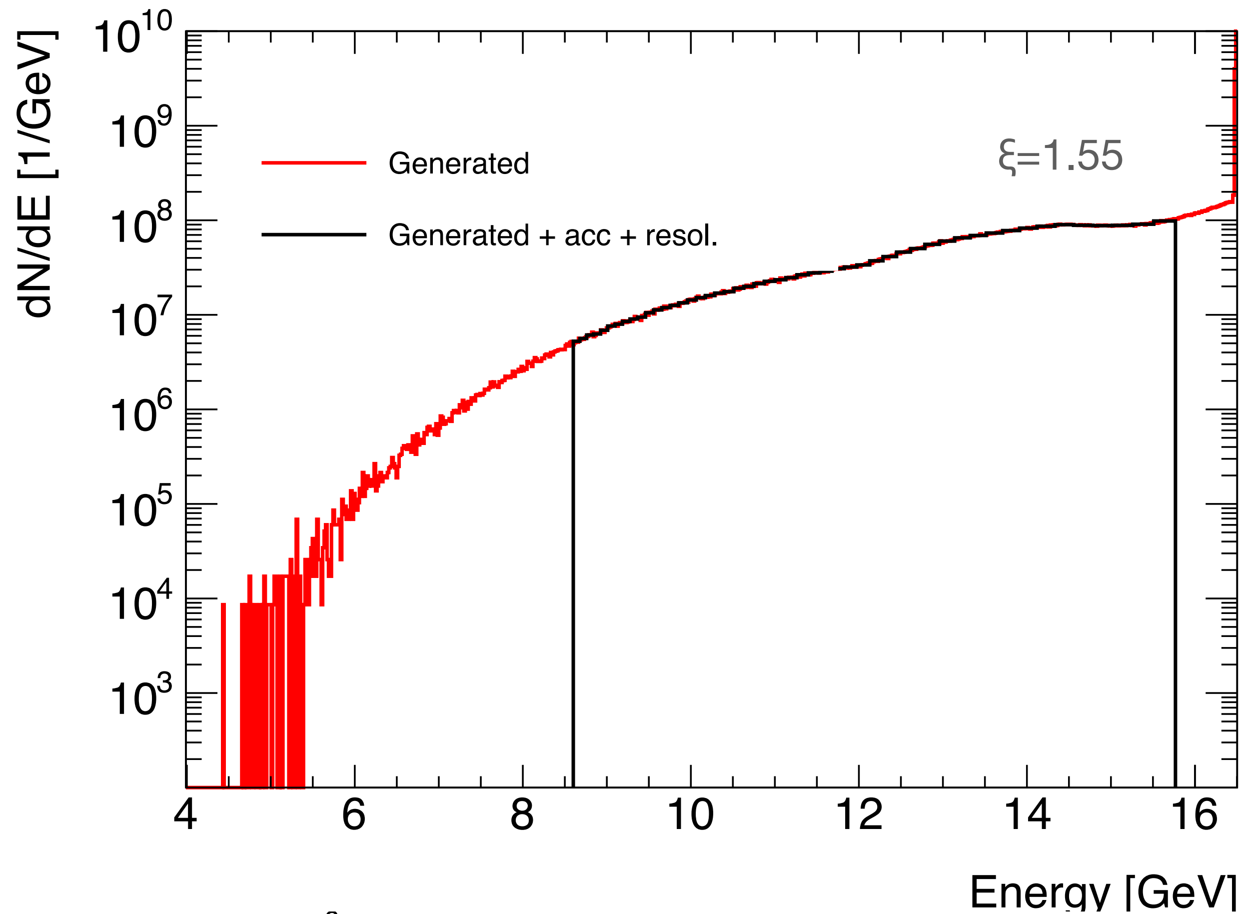


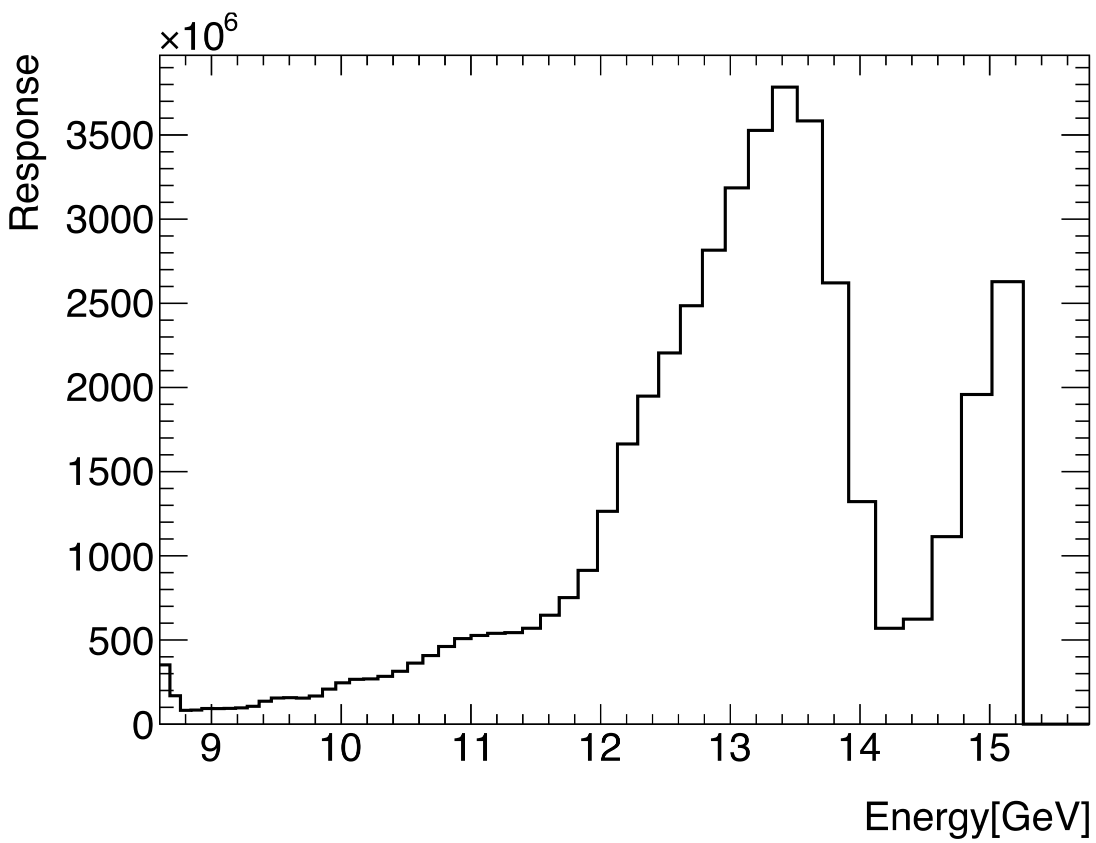


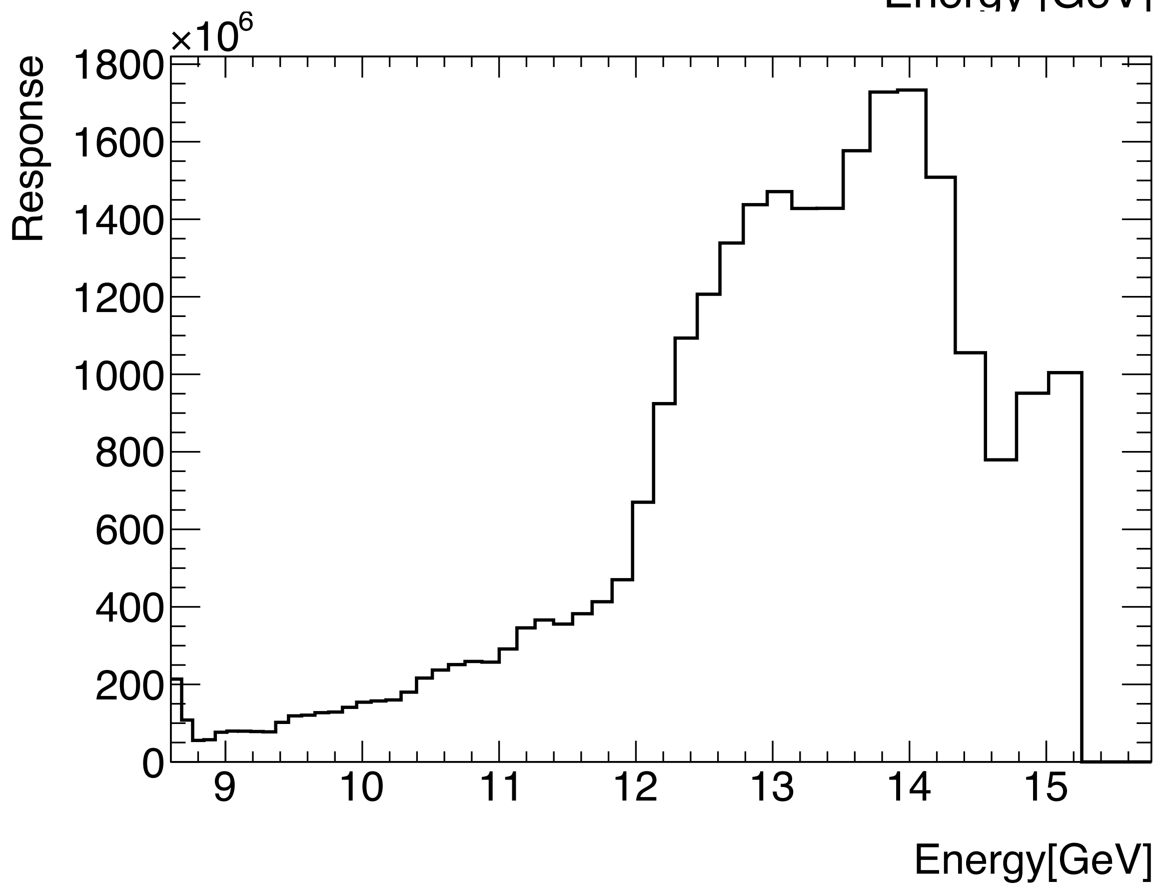


Spectra & Response

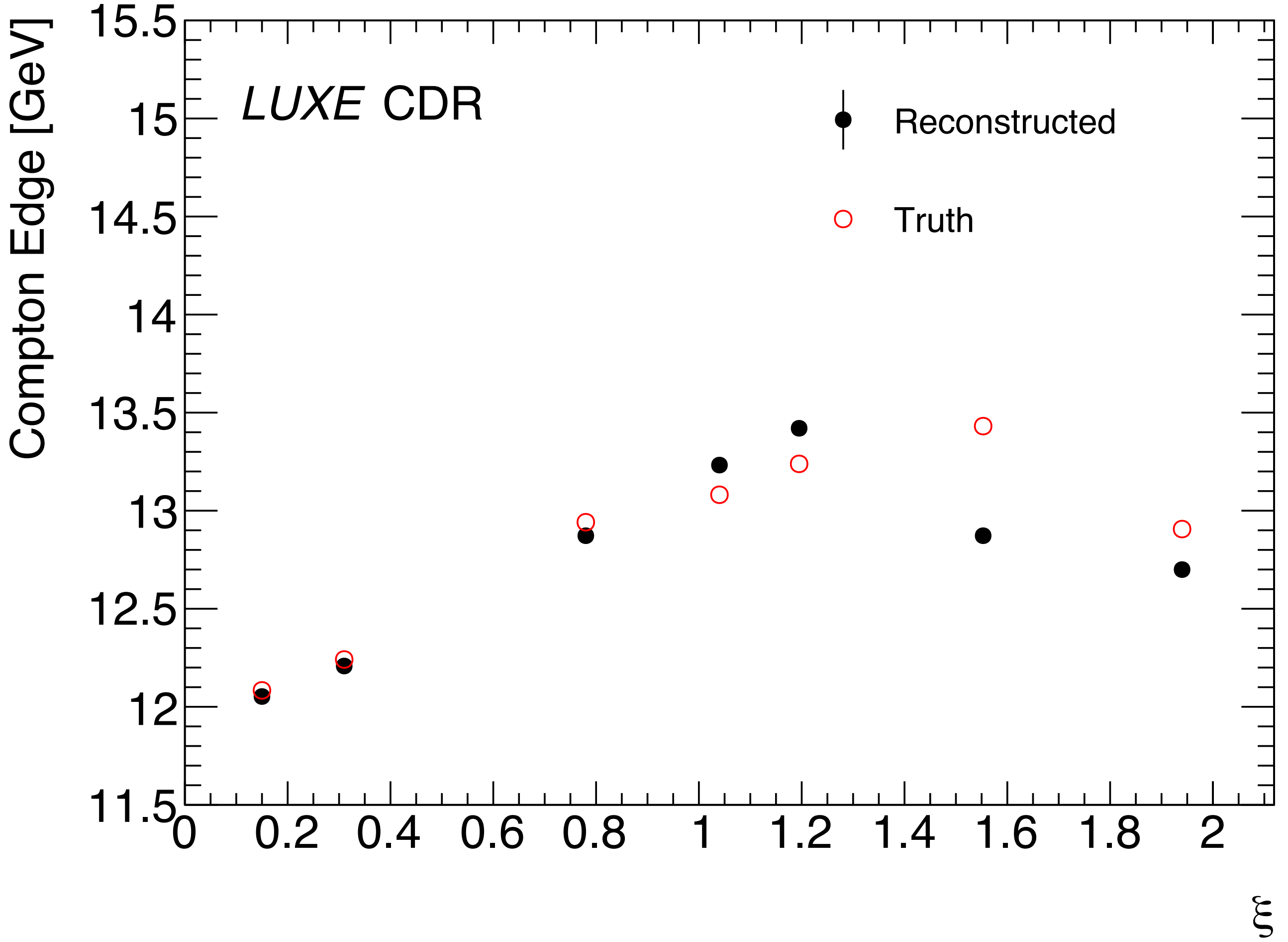






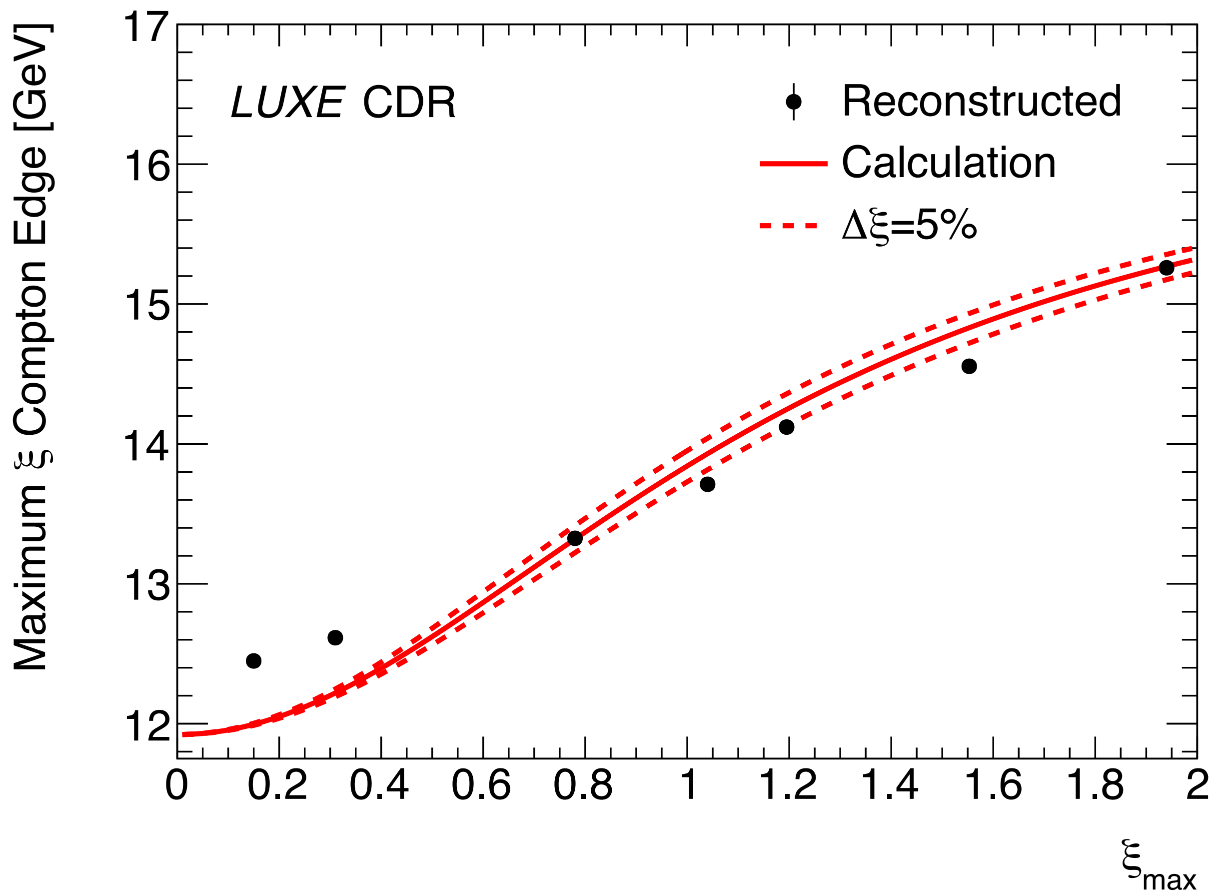


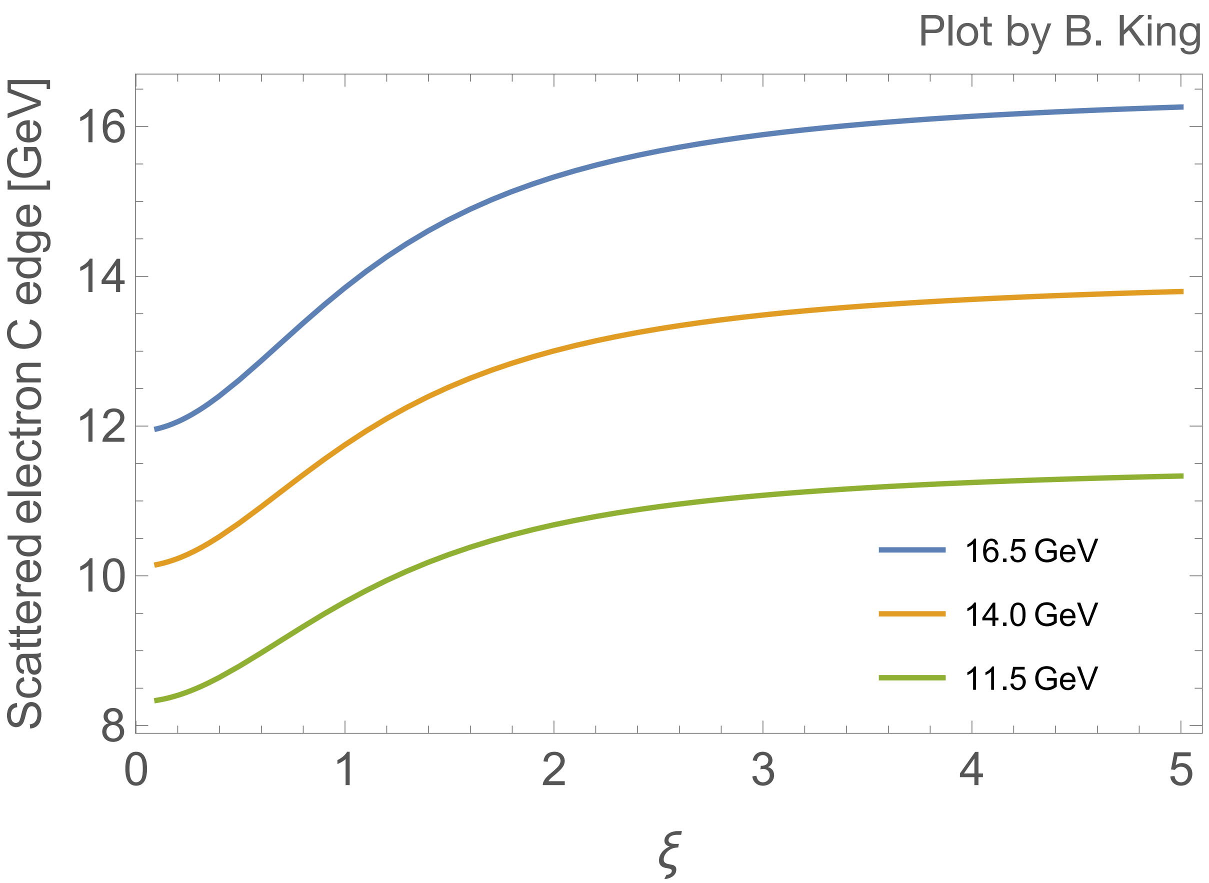
Edge Position (L) Reco vs. Generated



- Closure test: difference between generated and reco here is only due to binning

Kink Position (K_{up})





- the curve shows:

$$f(E)/\text{GeV} = 16.5\left(1 - \frac{2\eta}{2\eta + 1 + \xi^2}\right) \qquad \text{where } \eta = 0.192$$

- uncertainty of points not final, slight bias at low ξ

A first look at Cerenkov IP backgrounds

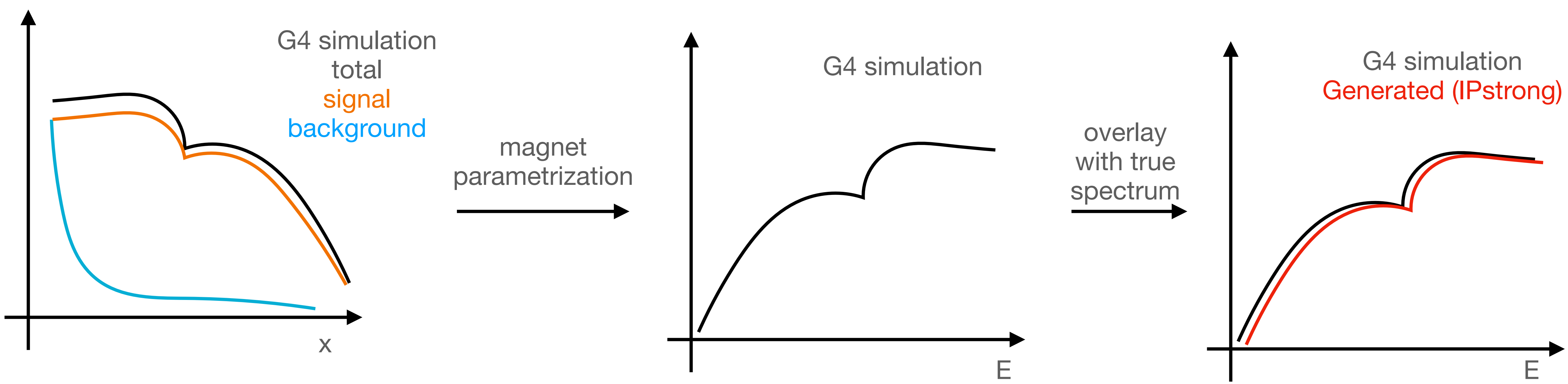
- Sasha ran a special e+LASER G4 sim with 2T magnetic field at ξ_{max}=0.78 (thanks!)

How to extract the "backgrounds":

1.) Select G4 events: - detid==6300 (hit Cerenkov sensitive volume)
- pdg==11 (electrons)
- E>20MeV (Cerenkov threshold)

2.) Get x-distribution, convert back to energy using dipole parametrization

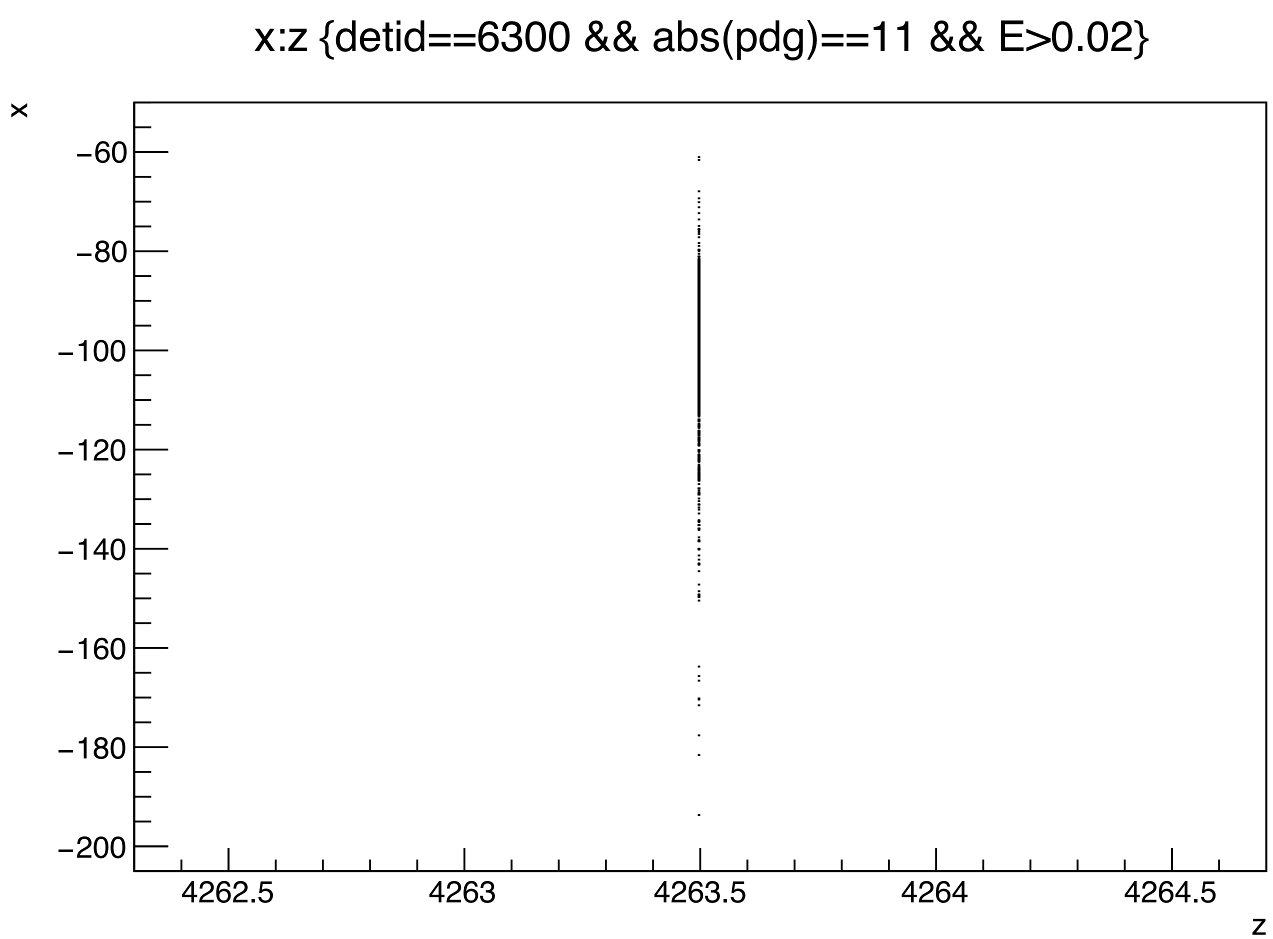
3.) Overlay with generated (signal-only!) energy spectrum from Tony's MC
→ difference is background

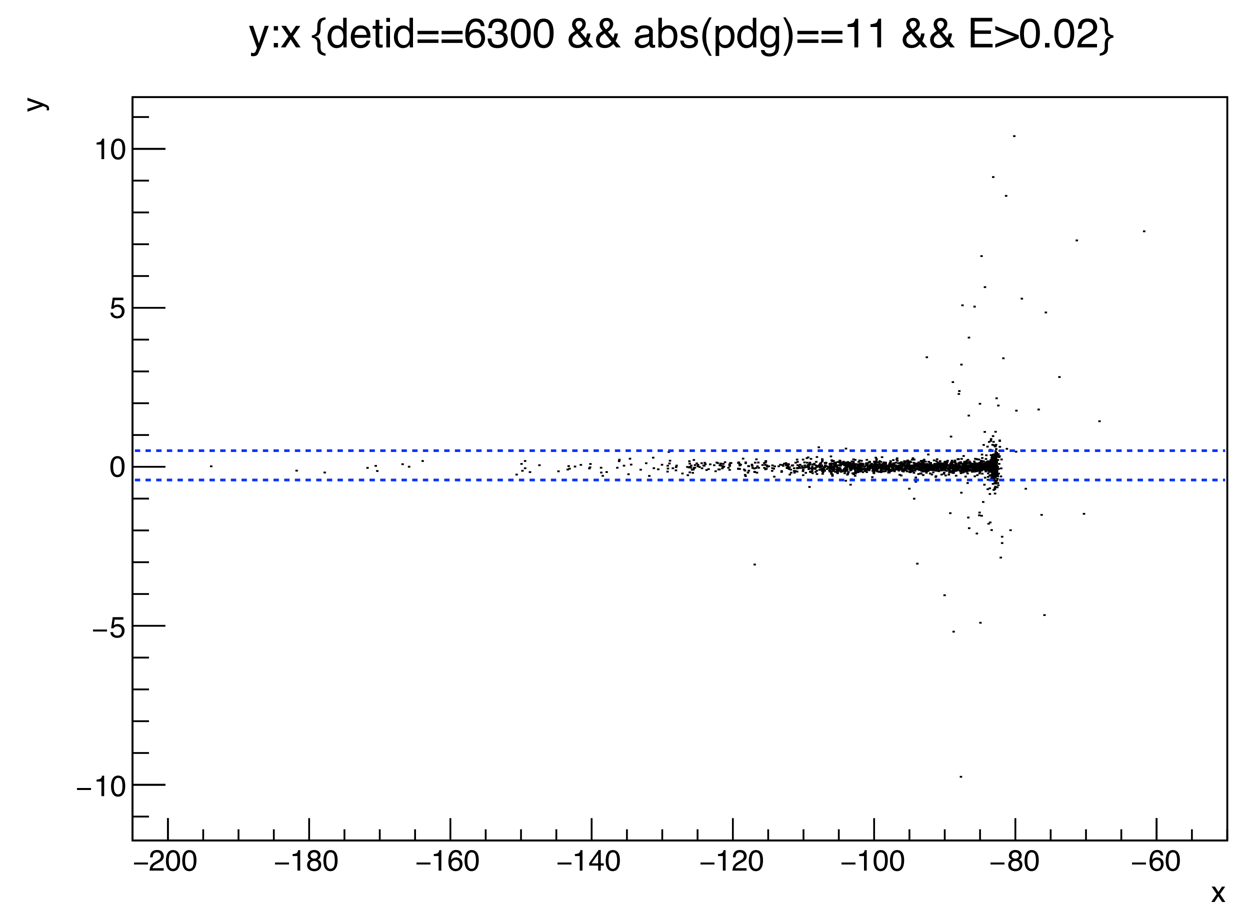


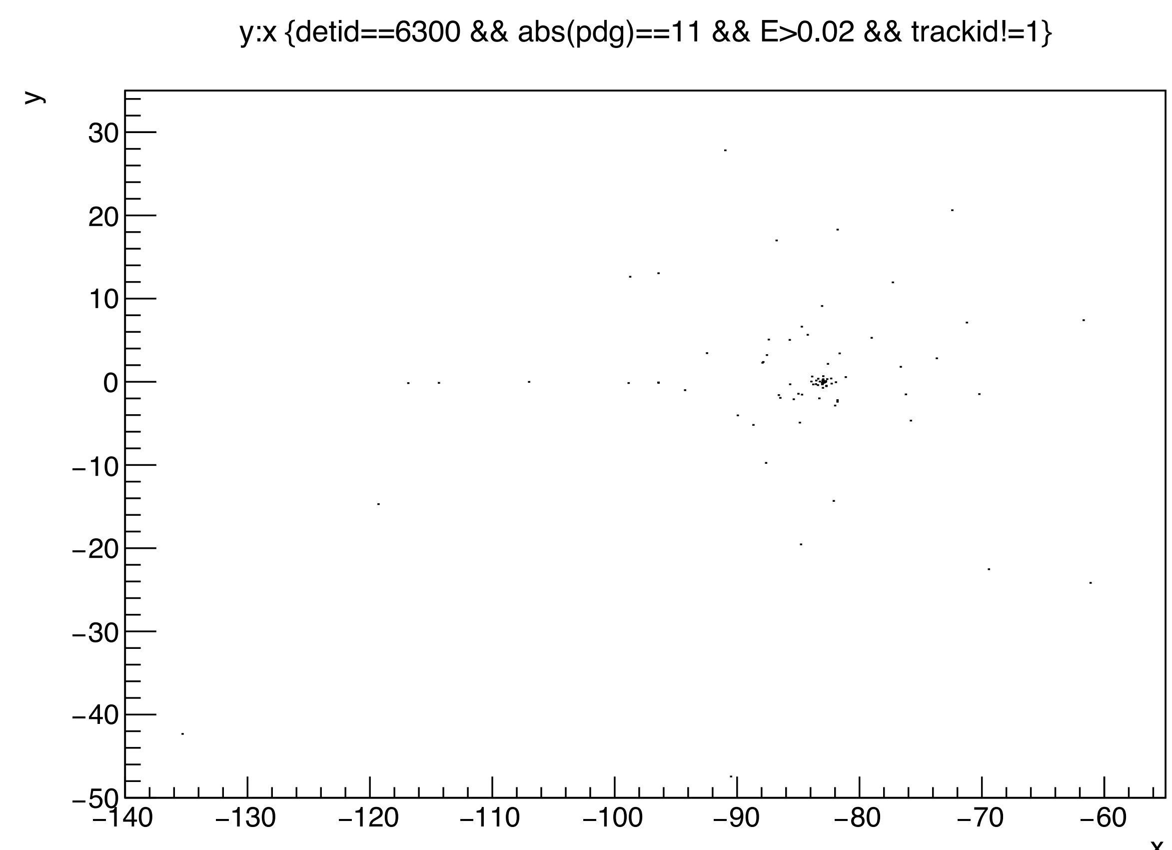
What is a good background estimate?

G4Sim-Generated?, Sim(trackid!=1)?

Some Facts about Particles at the IP Cerenkov

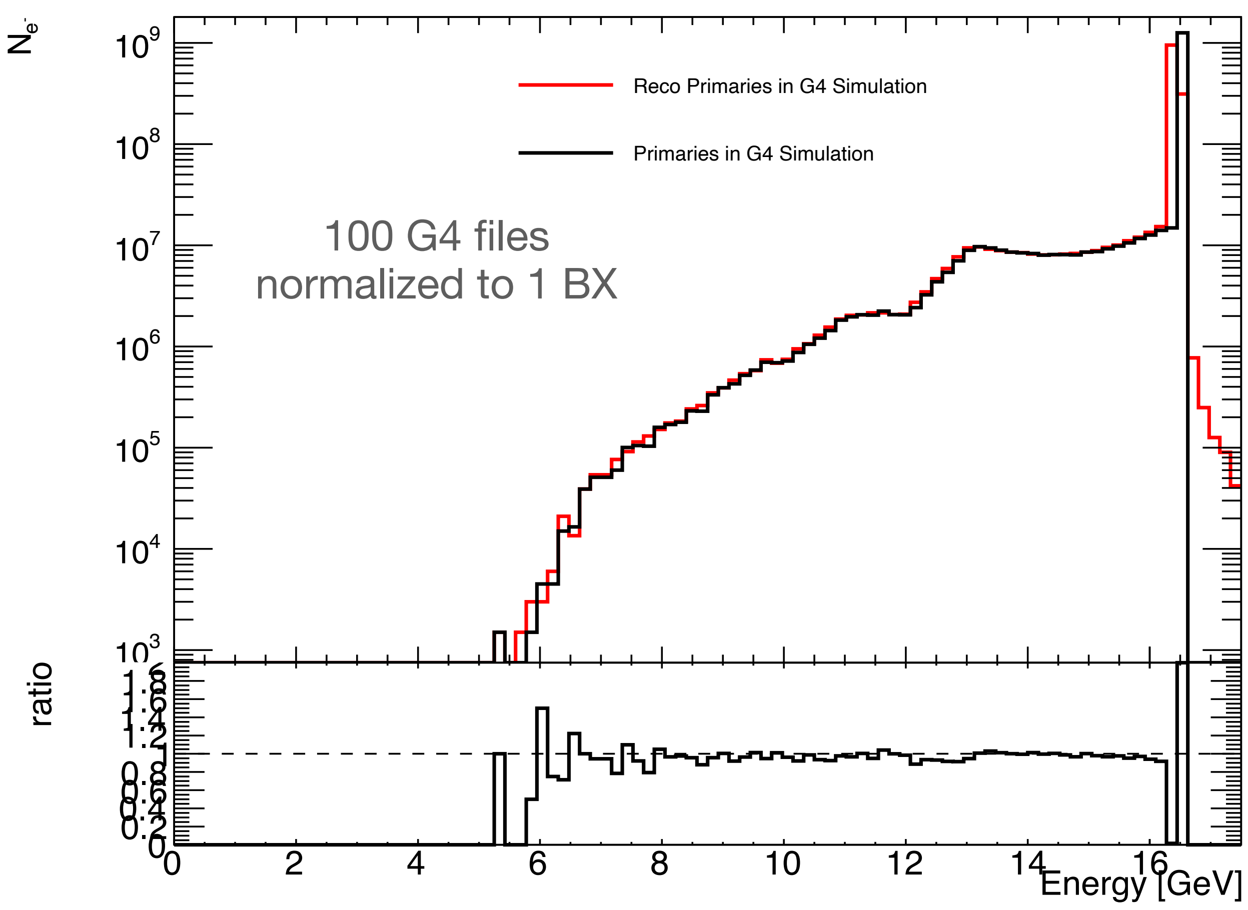


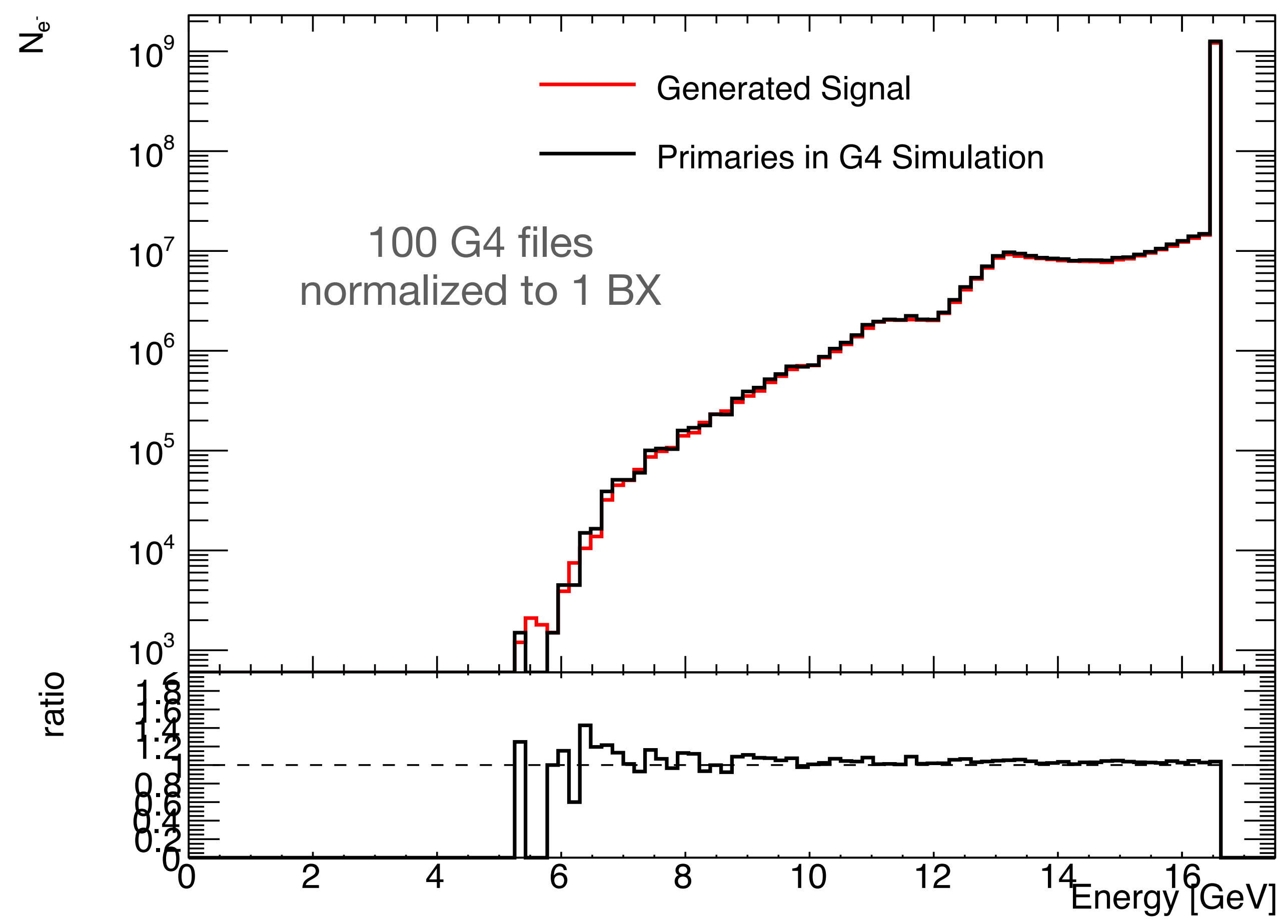




- all particles charged above Cerenkov threshold hit the detector from the front
- particles are very collimated
- most “non-primaries“ close to the beam

Sanity Cross-Checks

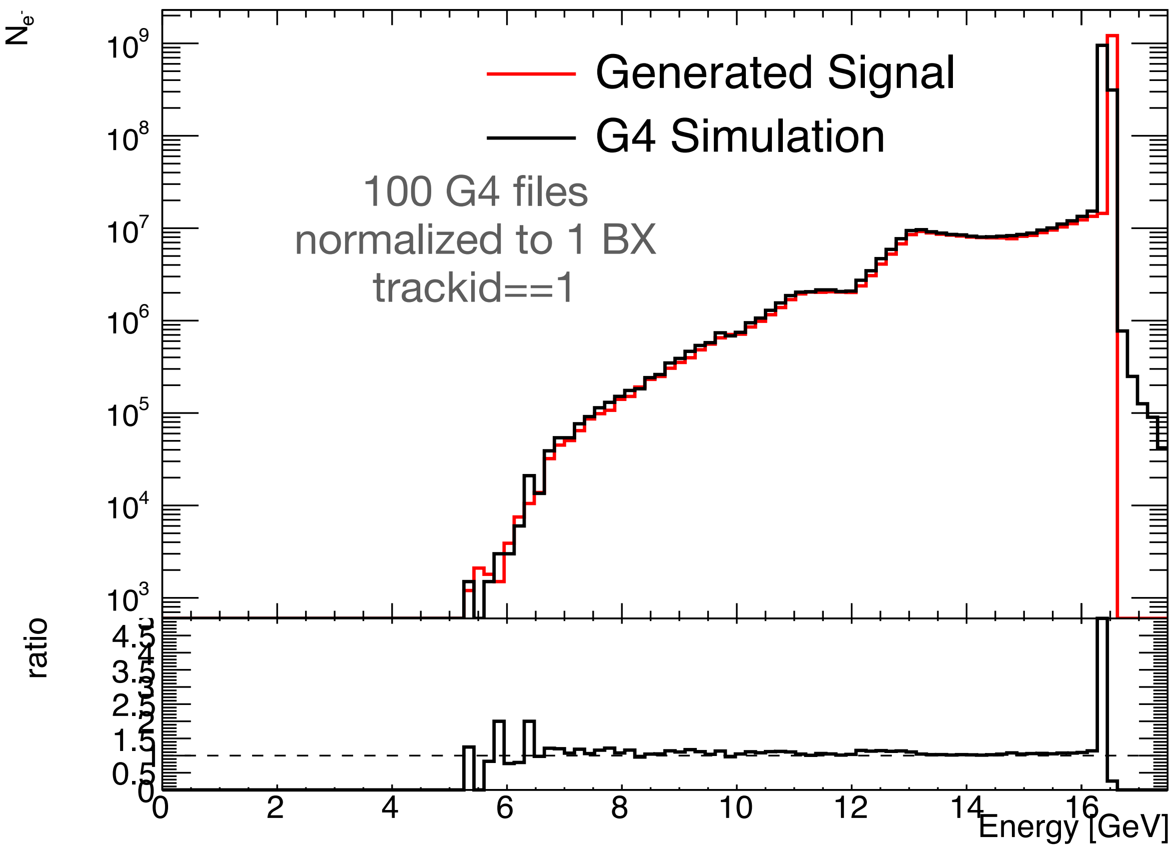


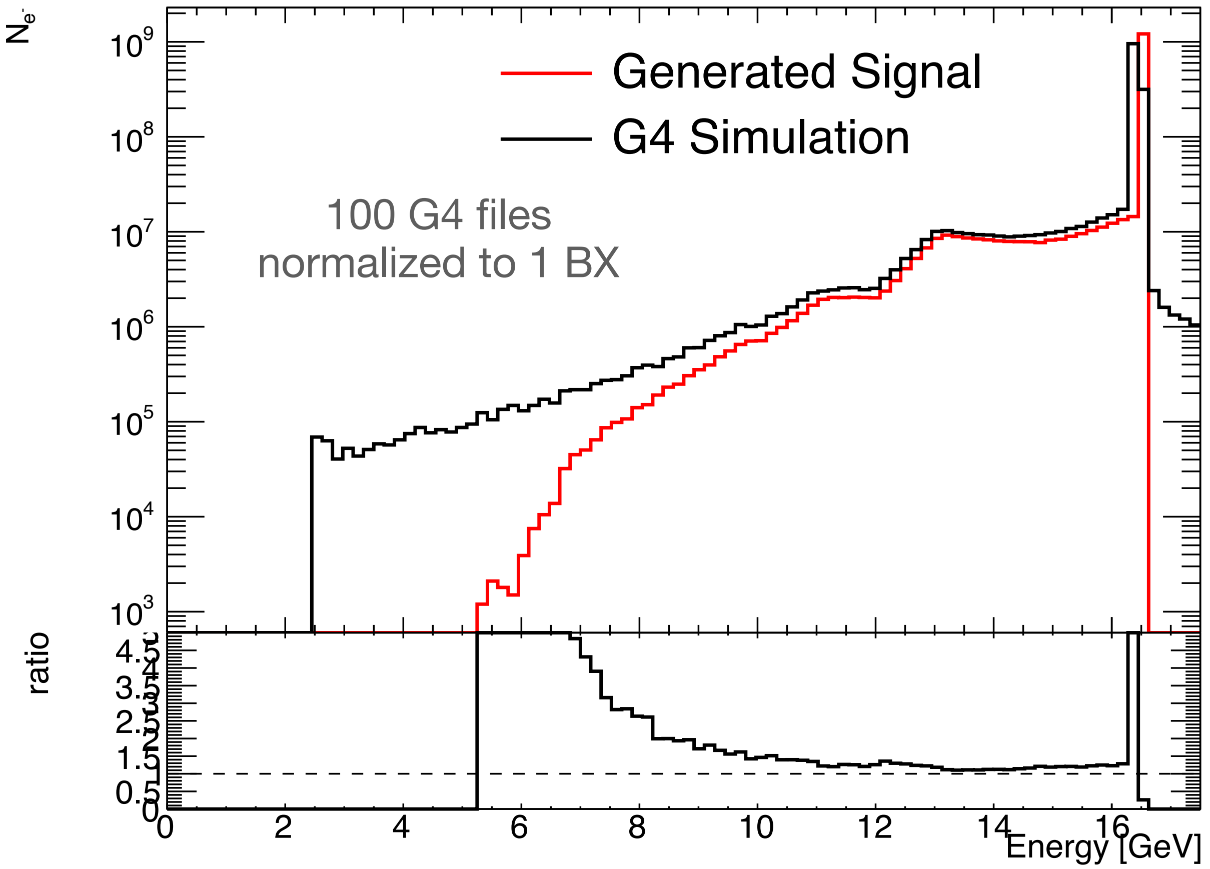


- "reco primaries": reconstructed from x-dist. of particles with trackid==1
- primaries: particles with detid==-1
- difference: difference between simmple B-field parametrization & actual field?

- generated: particles from Tonys MC
- primaries: particles with detid==-1

At the IP Cerenkov





- difference between generated